

SPH4U Sample Test - Momentum and Energy

Modified True/False

Indicate whether the sentence or statement is true or false. If false, change the identified word or phrase to make the sentence or statement true.

- _____ 1. The maximum work a force can do on an object occurs when the force is *parallel* to the direction of motion.

- _____ 2. Kinetic energy is a *vector* quantity. _____
- _____ 3. The change in gravitational potential energy *can never have* a negative value. _____
- _____ 4. A group of three balls at the top of three different frictionless ramps drop the same vertical distance *with the same final speed* regardless of the shape of the ramp. _____
- _____ 5. Linear momentum is a *scalar* quantity. _____
- _____ 6. The impulse is *always* in the same direction as the net force. _____
- _____ 7. *Momentum is not conserved* in all collisions. _____
- _____ 8. Momentum *cannot* be used during car collisions that involve cars with “crumple zones.”

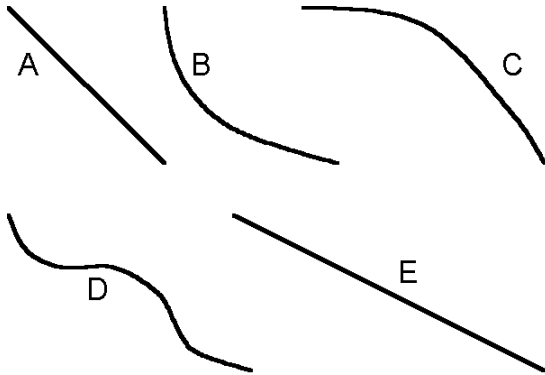
Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

- _____ 9. A child pulls a 7.4-kg toboggan 4.2 m across level ground with a 15-N force that is 34° above the horizontal. The work done is
 - a. 35 J
 - b. 52 J
 - c. 63 J
 - d. 3.9×10^2 J
 - e. 2.1×10^3 J
- _____ 10. The kinetic energy of a 24-kg dog running at 22 km/h is
 - a. 4.5×10^2 J
 - b. 5.8×10^3 J
 - c. 1.2×10^4 J
 - d. 2.6×10^2 J
 - e. 73 J
- _____ 11. A car slows down as it descends a hill. Which of the following is true?
 - a. the gravitational potential energy decreases
 - b. the kinetic energy increases
 - c. heat is produced by friction
 - d. two of A, B, and C are correct
 - e. all of A, B, and C are correct
- _____ 12. A spring with a force constant of 2.1×10^4 N/m compresses 3.5 cm when stepped on by a boxer. The mass of the boxer is
 - a. 65 kg
 - b. 73 kg
 - c. 75 kg
 - d. 82 kg
 - e. 740 kg
- _____ 13. A person running in a race has to pick up a mass equal to her own mass. Assuming she can still do the same amount of work, her speed will be changed by a factor of
 - a. 0.25
 - b. 0.5
 - c. 1
 - d. 2
 - e. 4

- b. 0.50
- c. 0.71

e. 2



- ____ 14. A race is set up with five balls placed at the top of the five ramps shown below and released at the same instant. Each ramp drops the same vertical height. The ramp that will allow the ball to arrive at the bottom first is
- a. A
 - b. B
 - c. C
 - d. D
 - e. E
- ____ 15. A bullet with a momentum of $2.8 \text{ kg} \cdot \text{m/s}$ [E] is travelling at a speed of 187 m/s . The mass of the bullet is
- a. 0.015 g
 - b. 0.067 g
 - c. 15 g
 - d. 67 g
 - e. not enough information
- ____ 16. A 55-kg person carrying a 5.0-kg ball slides along a horizontal frictionless surface. He tosses the ball perpendicular to his direction of travel relative to himself.
- a. His path will not change.
 - b. The ball will have a smaller angle from the original path than he will.
 - c. His speed does not change.
 - d. He speeds up.
 - e. He slows down.

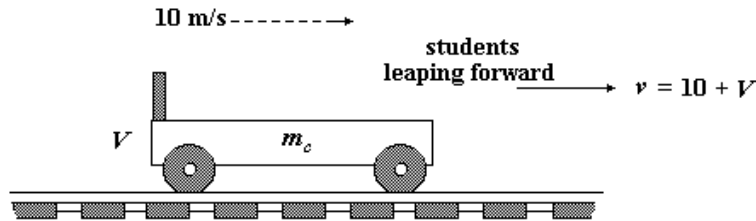
Short Answer

- 17. How much work is done to speed up a 2200-kg car from 12 m/s to 24 m/s ?
- 18. Give two observations that would enable you to conclude that the bounce of a superball is not a completely elastic collision.
- 19. What is the kinetic energy of a wagon of mass 15 kg whose momentum is $30 \text{ kg} \cdot \text{m/s}$?

Problem

- 20. A child swings on a swing so that her centre of mass is located 2.4 m from the point where the rope is attached to the tree. If she swings so that her maximum amplitude causes the rope to make an angle of 47° with the vertical, calculate the child's maximum speed during the swing.

21. A competition is held between two teams of physics students, each team made up of three members, and each member having a mass of 60 kg. The teams will take turns climbing onto a cart and jumping off. They want to see whose cart will be moved fastest by propelling it with a jump. They will start at the west end of a cart of mass 120 kg that is free to roll without friction on a level, east–west track. The plan is to run east along the cart and then jump off with a velocity of 10 m/s, with respect to the cart. The first team decides that its three members will run and jump off together. The second team decides that one member will depart according to the rules, followed by the second, and then, finally, the third. Calculate the final velocity of the cart for each team, and discuss the results. (Assume that vectors to the east are positive and omit vector notation.)



22. An 8.0 g bullet, moving at 400 m/s, goes through a stationary block of wood in 4.0×10^{-4} s, emerging at a speed of 100 m/s.
- What average force did the wood exert on the bullet?
 - How thick is the wood?
23. An artificial Earth satellite, of mass 2.00×10^3 kg, has an elliptical orbit, with a mean altitude of 400 km.
- What is its mean value of gravitational potential energy while in orbit?
 - What is its mean value of orbital kinetic energy?
 - What is its total energy while in orbit?
 - If its perigee is 280 km, what is its orbital velocity at perigee?

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Answer Section

MODIFIED TRUE/FALSE

- | | | |
|------------------------------------|----------|----------|
| 1. ANS: T
LOC: EM1.01 | REF: K/U | OBJ: 4.1 |
| 2. ANS: F, scalar
LOC: EM1.01 | REF: C | OBJ: 4.2 |
| 3. ANS: F, can have
LOC: EM1.01 | REF: K/U | OBJ: 4.3 |
| 4. ANS: T
LOC: EM1.03 | REF: K/U | OBJ: 4.4 |
| 5. ANS: F, vector
LOC: EM1.01 | REF: C | OBJ: 5.1 |
| 6. ANS: T
LOC: EM1.01 | REF: K/U | OBJ: 5.1 |
| 7. ANS: T
LOC: EM1.03 | REF: K/U | OBJ: 5.2 |
| 8. ANS: F, can
LOC: EM3.01 | REF: K/U | OBJ: 5.2 |

MULTIPLE CHOICE

- | | | | |
|------------|----------|---------------|-------------|
| 9. ANS: B | REF: K/U | OBJ: 4.1 | LOC: EM1.01 |
| 10. ANS: A | REF: K/U | OBJ: 4.2 | LOC: EM1.01 |
| 11. ANS: D | REF: K/U | OBJ: 4.2, 4.3 | LOC: EM1.01 |
| 12. ANS: C | REF: K/U | OBJ: 4.5 | LOC: EM1.08 |
| 13. ANS: C | REF: K/U | OBJ: 4.2 | LOC: EM1.01 |
| 14. ANS: B | REF: K/U | OBJ: 4.3 | LOC: EM1.01 |
| 15. ANS: C | REF: K/U | OBJ: 5.1 | LOC: EM1.01 |
| 16. ANS: D | REF: K/U | OBJ: 5.4 | LOC: EM1.03 |

SHORT ANSWER

18. ANS:
- The ball does not reach its original height after the bounce. (some loss of energy)
 - Sound is produced. (sound energy must come from original kinetic energy)

REF: K/U OBJ: 5.3 LOC: EM1.04

19. ANS:

REF: K/U
MSC: SP

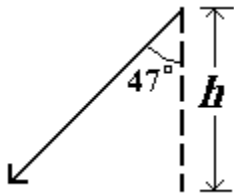
LOC: EMV.01

KEY: FOP 9.2, p.342

PROBLEM

20. ANS:

Calculate the vertical displacement of the pendulum (swing):



$$\cos \theta = \frac{\text{ADJ}}{\text{HYP}}$$

$$\text{ADJ} = \text{HYP} \cos \theta$$

$$= 2.4 \cos 47^\circ$$

$$\text{ADJ} = 1.637 \text{ m}$$

$$\text{vertical height} = 2.4 - 1.637 = 0.763 \text{ m}$$

The maximum speed at the bottom will involve zero E_g and the maximum height at the top has no E_k , so

$$mg\Delta y = \frac{1}{2}mv^2$$

$$v = \pm\sqrt{2g\Delta y}$$

$$= \pm\sqrt{2(9.8\text{ m/s}^2)(0.763\text{ m})}$$

$$v = 3.9\text{ m/s}$$

The child's maximum speed is 3.9 m/s

REF: K/U

OBJ: 4.4

LOC: EM1.03

21. ANS:

For the first team:

Let the velocity acquired by the cart with respect to Earth be V . The velocity of the three students relative to the Earth, v , will be $10 + V$.

Note: The negative sign for V indicates a velocity to the west.

For the second team:

Let the velocity of the cart after each successive student has jumped be V_1 , V_2 , and V_3 , and let the velocities of the three students relative to the Earth be v_1 , v_2 , and v_3 . After the first student has jumped:

After the second student has jumped:

Finally, after the third student has jumped:

As can be seen from the result, the team that chose to have its members jump separately was able to give the cart a greater velocity in the opposite direction.

REF: K/U, I

OBJ: 5.2

LOC: EM1.02

KEY: FOP 8.3, p.302

MSC: SP

23. ANS:

$$r_0 = r_e + 400 \text{ km}$$

$$(a) = 6.37 \times 10^6 \text{ m} + 0.40 \times 10^6 \text{ m}$$

$$= 6.77 \times 10^6 \text{ m}$$

(b) For orbit:

$$E_k = \frac{1}{2} |E_\epsilon|$$

$$= 5.89 \times 10^{10} \text{ J}$$

$$E_T = E_\epsilon + E_k$$

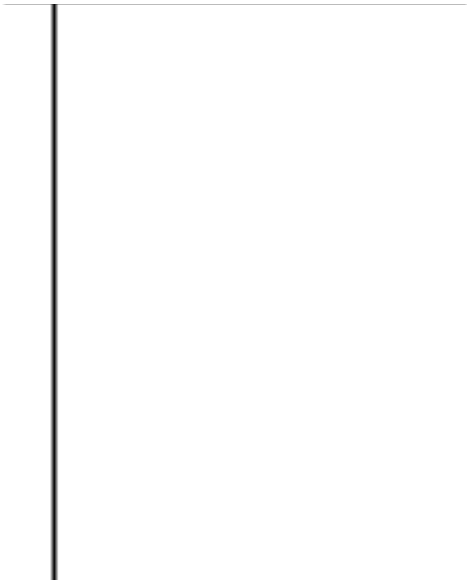
$$(c) \quad = -1.18 \times 10^{11} \text{ J} + 5.89 \times 10^{10} \text{ J}$$

$$= -5.89 \times 10^{10} \text{ J}$$

(d) At perigee:

$$r_p = 6.37 \times 10^6 \text{ m} + 0.28 \times 10^6 \text{ m}$$

$$= 6.65 \times 10^6 \text{ m}$$



REF: K/U OBJ: 6.3 LOC: EM1.07 KEY: FOP 10.8, p.404
MSC: P17.17.17.17.